California Forest Experiment Station

Technical Note No. 2

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Special
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Erosion Control

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USE OF VEGETATION FOR EROSION CONTROL IN MOUNTAIN MEADOWS

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Structures built to control gullying in mountain meadows are, in general, of a temporary nature. Vegetation must be depended on to make this control permanent. Normally, controlled gullies will revegetate naturally in time, but, to hasten vegetative growth and to make it more effective, planting and seeding should be resorted to. The principal methods of artificial revegetation at present employed in California are the planting of willow cuttings, the planting of sod, and seeding. It should be emphasized that the sowing of seed appropriate to the locality, whether of grass, shrub or tree species, should be included in all projects as a most desirable supplement to other control methods.

WILLOW PLANTING

One of the quickest and surest ways to secure a vegetative protection is the planting of willow cuttings. General instructions for the planting of willows are given in Technical Note No. 1, of this Station, entitled Willow Cuttings for Erosion Control. Specific directions for planting willows in mountain meadows are given below.

A. Selection of Species

Wherever possible vigorous native brush species of willow should be used. Species having long, straight stems are much easier to cut than those with crooked stems, and provide stakes that are much easier to drive.

In general it is preferable to use species which have browse value, but in meadows which are very heavily grazed a plantation of palatable willows may be completely destroyed by grazing animals. In such cases non-browse species should be mixed with the browse species. In each

locality a little observation will determine which willows are eaten most readily and which are left untouched by grazing animals. Deer usually do little damage in comparison with domestic livestock.

B. Time to Plant

Stakes should be cut and planted when the willows are dormant. This period extends from the time the leaves start to turn yellow in the autumn until the time when growth starts in the spring. In moist soils, willow stakes can sometimes be successfully planted during the summer season, but in general this should not be attempted.

C. How to Cut Stakes

In general the stakes should be 1/2 to 2 inches in diameter, and about 18 inches long.

Stems up to 1½ inches in diameter can best be cut from the bush with two-handled brush pruning shears. Larger branches can be cut with axes.

The quickest method to cut the stems into the 18 inch lengths is to use a sharp hand ax or a sharp chisel-edged machete and a chopping block. It may be convenient to have markers on the chopping block 18 inches apart or to set up a back-stop board 18 inches from a mark on the block, so that the proper length can be quickly gaged. When no chopping block is available, the stems can be readily cut with the brush pruning shears.

It is important that the stakes be piled as cut with the butts all at one end of the pile. This should prevent the cuttings from being planted wrong side up. Bundles of stakes can be bound together with baling wire for transporting to where they will be used. The stakes should be planted as soon as possible after they are cut and should be protected from excessive drying at all times.

D. How to Plant Stakes

1. The cuttings must be planted right side up; i. e., with the butt ends in the ground.

2. Set cuttings as deep as possible up to 2/3 of their length.

3. In fairly soft soil the stakes can be driven with a wooden maul, constructed as shown in Figure 1. Do not use an ax or a sledge.

4. In hard soil holes should be prepared for the stakes with a crow-bar to prevent excessive stripping of the bark.

5. Cuttings should be set at a slight downstream angle rather than vertical. This lessens the chance of their being uprooted by the current.

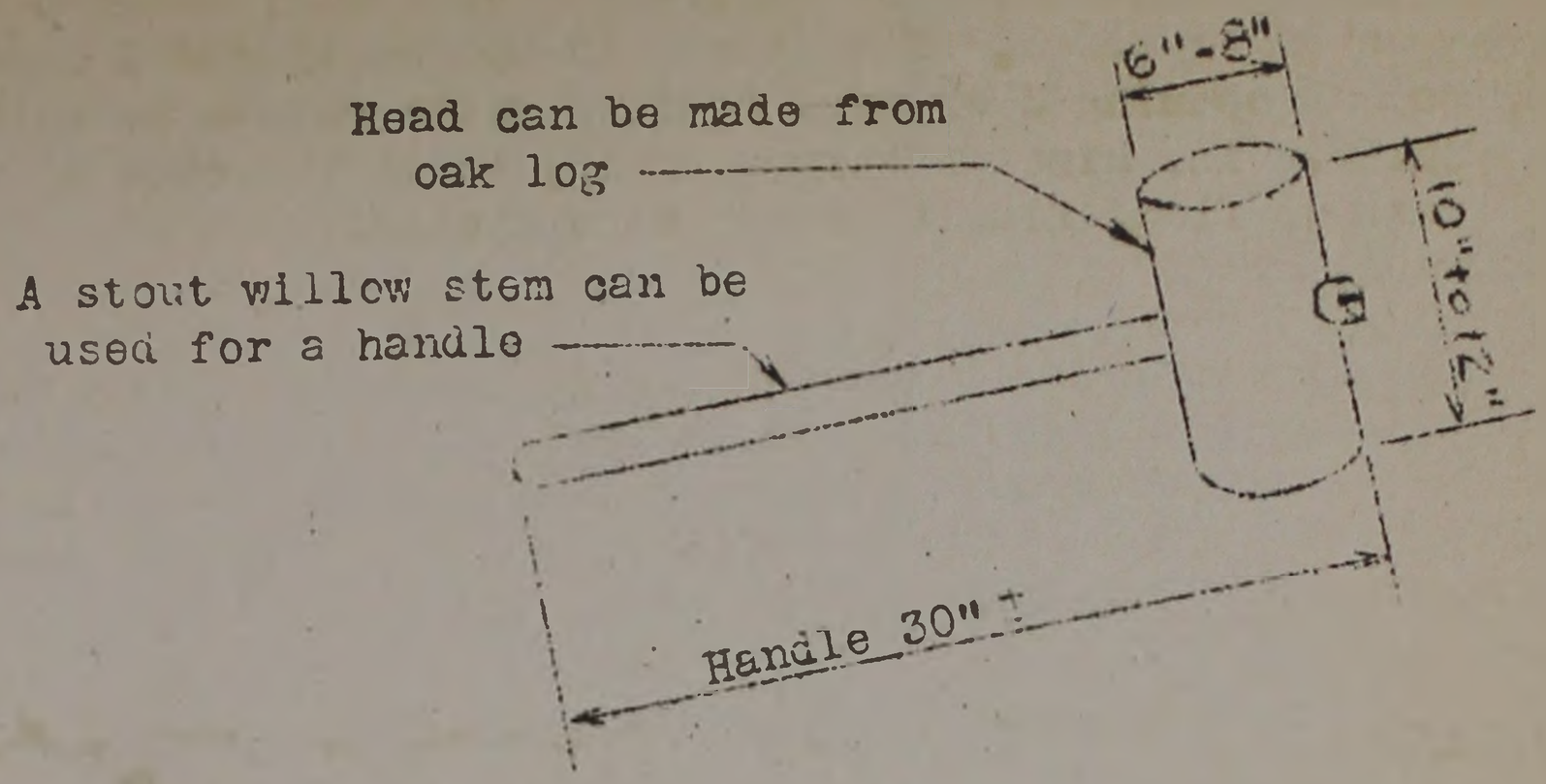

Figure 1.
Wooden Maul for Driving Willow Stakes

E. Where to Plant Willow Stakes

1. To reinforce check dams.

For strengthening check dams, willow cuttings should be planted as shown in Figure 2. Normally, the stakes should be spaced 1 foot to 18 inches apart. On large dams willows should also be planted at the points marked "secondary" on the drawing. This secondary planting consists in extending the willows part way around the upstream face of the dams, and in planting another row about 2 feet downstream from the apron. Note that no willows are to be planted in the center of the channel. Spaces sufficiently wide to pass off flood flows must be provided, otherwise floods may tend to open up new gullies around the dams. Normally, in small meadows near the headwaters, this channel opening need not be more than 3 or 4 feet wide.

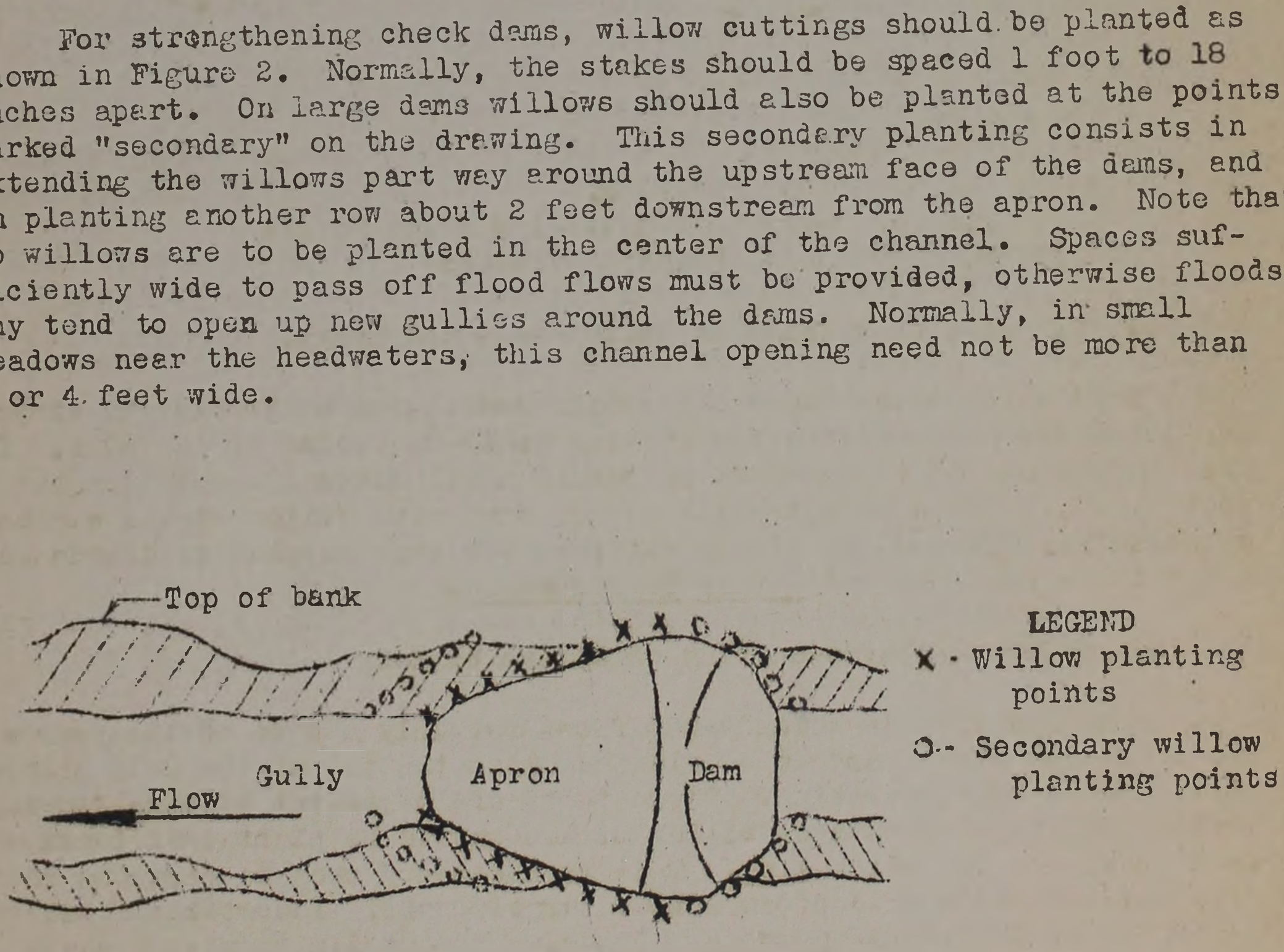

Figure 2.
Plan of Gully Check-Dam Showing Points for Planting Willows

2. To reinforce gully-head controls.

For the strengthening of gully-head controls, willows should be planted as shown in Figure 3, The stakes should be spaced 1 foot to 18 inches apart, and an opening 3 or more feet in width should be left in the center of the gully. The size of this opening, as in the case of dams, depends on the maximum flood flow that can be expected.

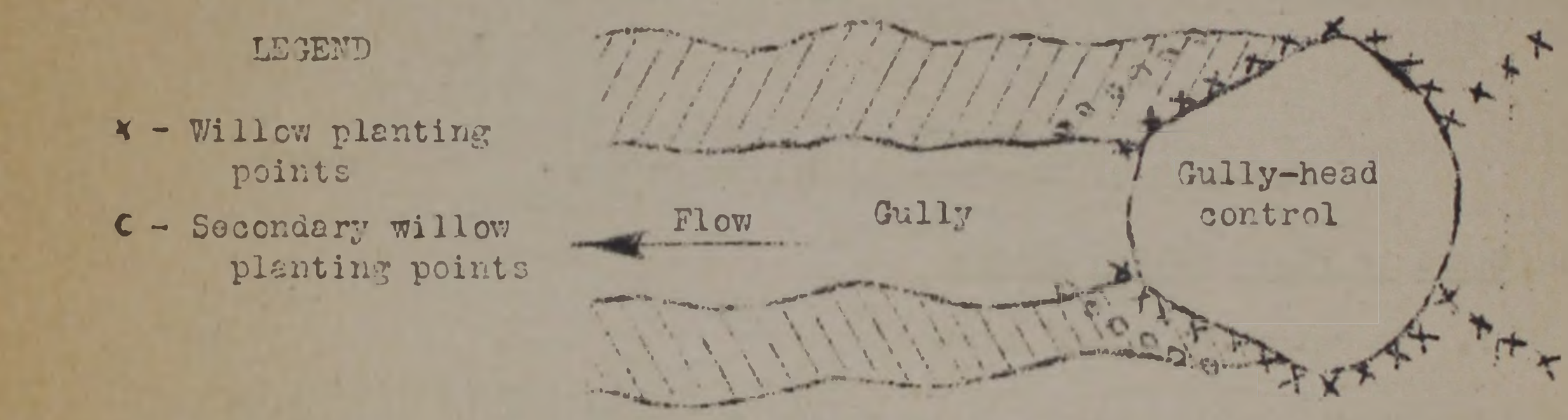

Figure 3.
Plan of Gully-Head Control Showing Points for Planting Willows

3. For steking wattles in gully heads and banks.

"Dry" gully heads and banks should usually be controlled by sloping off the banks and heads to the natural angle of repose of the soil, To hold this slope during periods of runoff until natural vegetation has it stabilized, wattles of cut brush pegged down with willow stakes can be constructed. The use of willow cuttings for this purpose is discussed under the section headed Wattle Construction.

4. To prevent side-cutting of stream banks.

In dry gullies in which water flows for only a part of the year a row of willow stakes should be planted along the toe of the bank slopes where the banks are eroding. Where there are perennial streams flowing in the gullies, the rows of willow stakes should be planted at least one foot above the low water line. This is necessary because vigorous roots will not develop in a continuously saturated soil. The stakes should be spaced about 18 inches apart in the row. The outside curves of sharp bends in the streams will often be found to be eroding, and in need of such protection.

5. For protection of meadows not controlled with dams.

Some gullies can not be satisfactorily controlled by the construction of dams. Either the gully is relatively shallow, or the slope is too great for the safe use of check-dams, or both. In any case, the planting of willows in clusters at intervals along the gullies will be found beneficial. Figure 4 illustrates the method of planting one cluster. The distance between willow clusters normally depends upon the gradient of the gully bottom. The steeper the gully grade, the closer together the clusters should be. Usually the spacing can vary from 500 feet with a gully gradient of 1% to 25 feet with a gully gradient of 20%.

In the rows of willows shown in Figure 4, the stakes should be 1 foot to 18 inches apart in the rows and the two rows should be about 4 feet apart. The rows should extend from the top of the bank downstream to the toe.

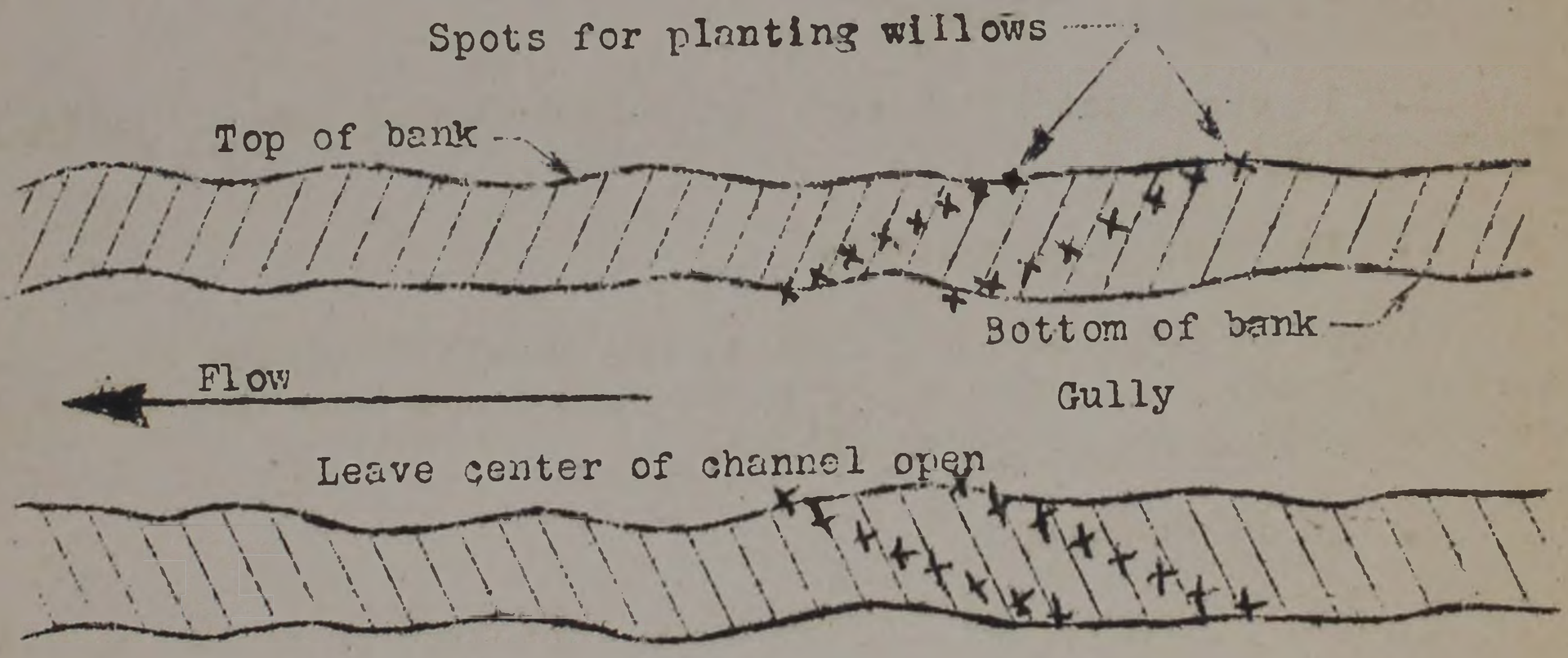

Figure 4.
Plan of Gully Showing Planting Points
of a Willow Cluster

6. To control small side gullies.

In small "V"-shaped side gullies willows should be planted in a continuous row along the bottom of each gully, spacing the cuttings about 2 feet apart.

SOD

The heavy sod usually found in mountain meadows is an excellent protection against erosion. Strips of such sod, planted in key spots or in contour strips, will soon spread and form a strong cover for the soil. Care should be used to dig sod from level places in the meadow where there is no danger of starting fresh erosion.

Sods should not be planted until just before or during wet seasons, except when planted in soil that is continually damp. Where the soil is always damp, the sods may be planted at any time. As a rule, it is best to obtain the sod from the immediate locality in which it is to be planted. Plant the sod as soon as possible after cutting. If it is necessary to delay planting for a day or two, keep it moist. The sod is most readily cut with an axe-mattock or spade, and lifted with a square-pointed shovel. Sod should be planted so that the ground surface of the sod is slightly below the surface of the ground in which it is being planted. Where grass is already growing in a gully, it is of course unnecessary to plant sod.

Sod is used as follows:

1. In constructing wattles (discussed under section on WATTLE CONSTRUCTION)

2. In gully head controls

Blocks of sod about one foot square should be placed at 3 foot intervals around gully head controls in such a position that it is protected from the full force of heavy floods.

3. On check-dams

Strips or patches of sod about one foot wide or square should be planted in open spots between the gully bank and the dam and apron to prevent undercutting. Similarly, strips of sod planted in a contour line one foot wide along the sides of the basin, upstream from the dam, will hasten the revegetation of the slope and the surface of the expected fill above the dam.

WATTLE CONSTRUCTION

Most meadow gullies have vertical sides with rims of overhanging sod. Unless corrected, this condition continues by constant undercutting of the sides. This process is most rapidly checked by cutting down the vertical slopes to a natural angle of repose, i. e., a slope of 70 per cent or less depending on the soil type.

After the slope has been cut down, it is usually necessary to protect it until vegetation becomes fully established. The prevention of side cutting by the stream in the gully bottom has previously been described. However, such methods do not stop erosion caused by water flowing down the slope into the gully, a condition particularly noticeable where side gullies are forming, and in "dry" gully heads subject to erosion only during infrequent floods.

A system of contour "wattle" construction as used on road slopes, can be adapted to the control of these gully slopes. A wattle is a continuous bundle of cut brush, hay or other vegetation packed into a small contour trench to hold the soil and interrupt the flow of any water down the slope. It is necessary to space such wattles every 2 to 4 feet, slope distance.

Locations Where Wattles Can Be Used

1. On banks which have been sloped off, and where side gullies have started, or are apt to start, from runoff from the meadow land above.

2. On banks which erode during the melting of snow. Such banks are characterized by a loose soil, by very little vegetative cover, and by being already sloped to the natural angle of repose of the soil.

3. On wide or deep gully heads, too large for the ready construction of the usual gully-head controls.

4. On gully heads where the headward erosion is caused more by the loose condition of the soil than by severe floods.

Common Types of Wattles

Type A. Sod wattles: These consist of continuous strips of sod cut from the overhanging banks or from flat areas further back in the meadow where there is no danger of starting fresh erosion spots. The strips should be about 10 inches or one foot wide, and spaced about 30 inches apart, slope distance. For this planting actual terraces need not be made; the strips of sod are bedded firmly into the slope as shown in Figure 5.

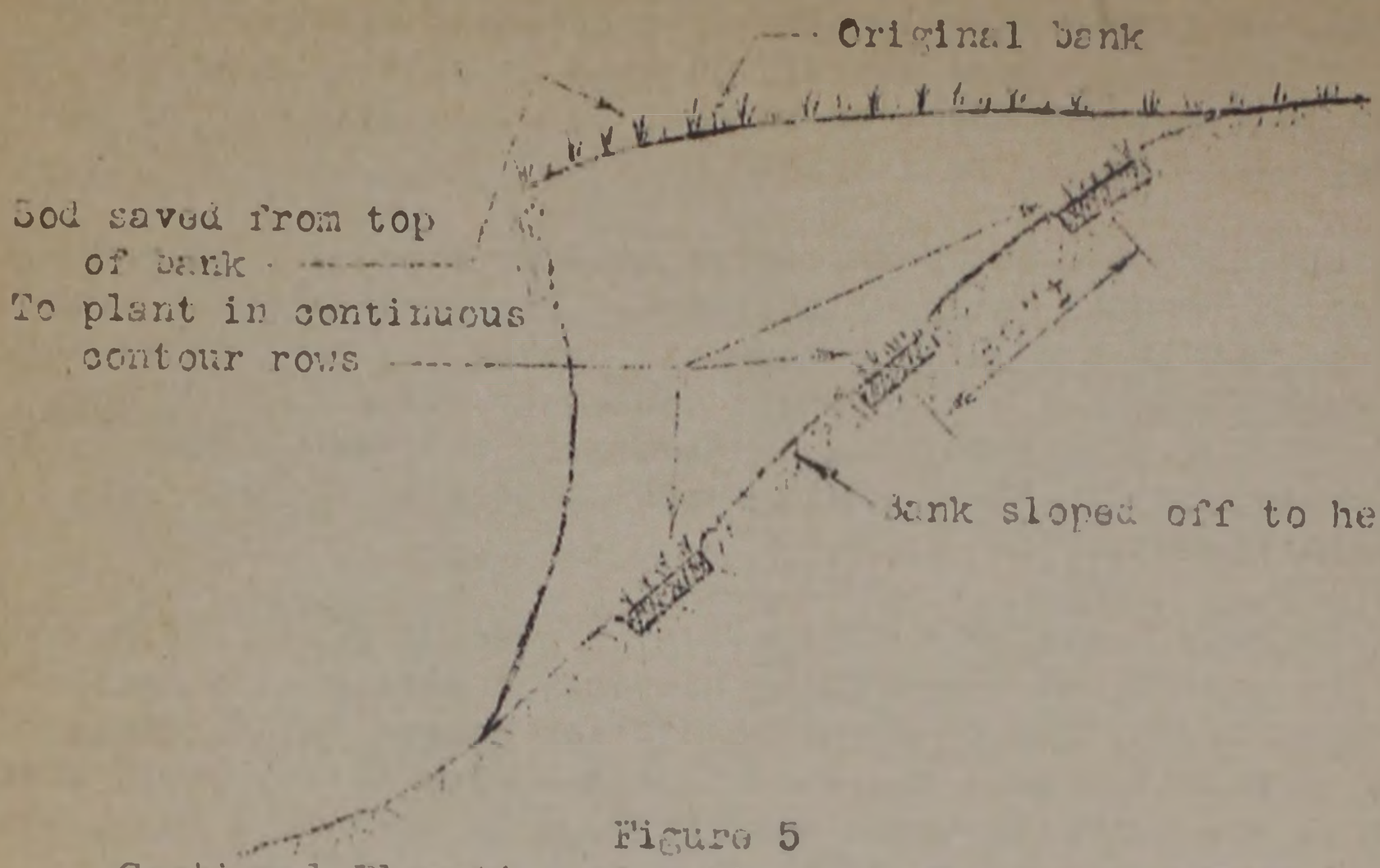

Figure 5
Sectional Elevation of Gully Bank Showing Sod Wattles

Type B. Hay or pine needle wattles: constructed by cutting small trenches around the slopes on the contours and by filling the trenches with continuous "ropes" or bundles of pine needles or hay. These "ropes" are made by merely bundling the loose hay or pine needles together with the hands, and tucking it into the trenches. The "rope" should be 2 or 3 inches in diameter. Earth from the slope above will work down and partially cover the material. These wattles should be spaced about 30 inches apart, slope distance.

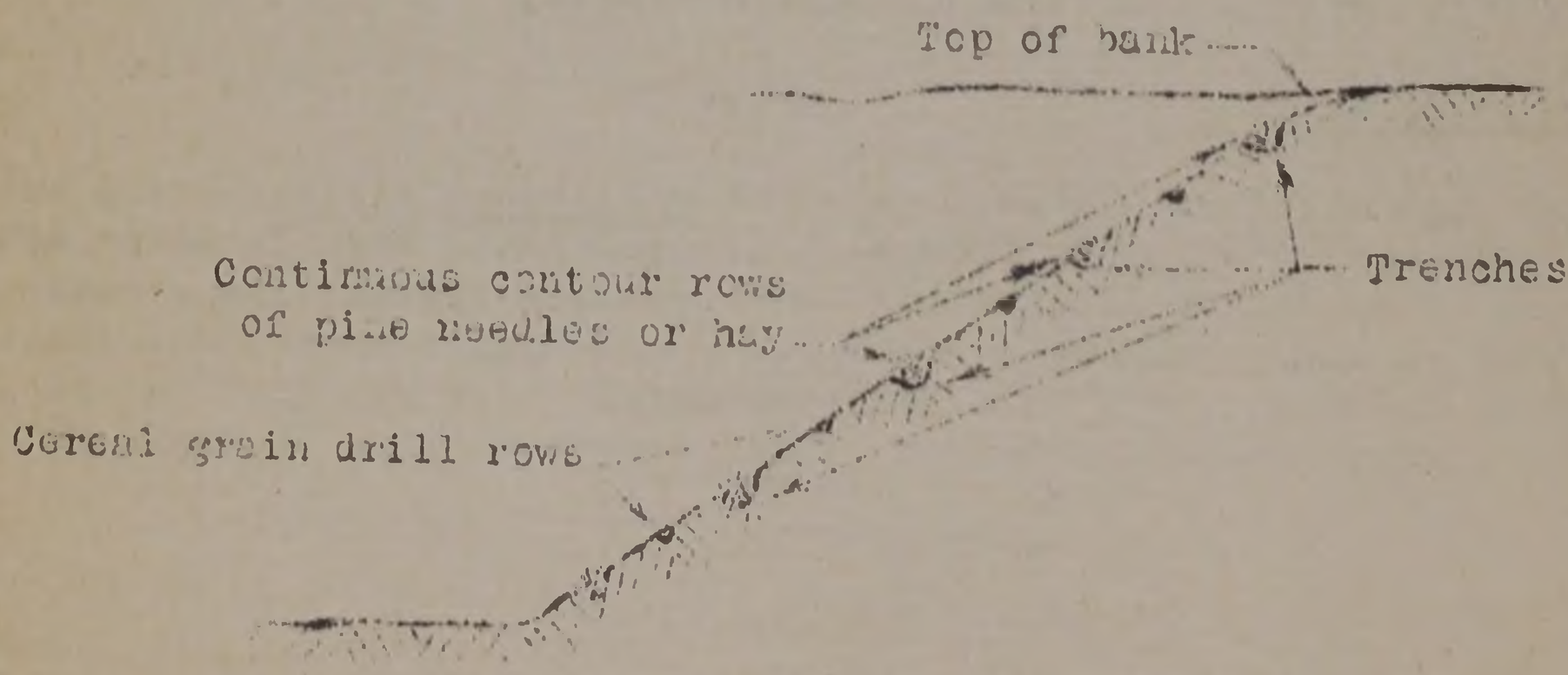

Figure 6
Side Elevation of Gully Head Showing Type B Gully Wattles

Type C. Wattles constructed of willow stakes and pine needles or hay: This type, illustrated in Figure 6, is constructed as follows:

1. About 30 inches up from the bottom of the gully drive a row of willow stakes along the contour. These may be the standard willow cuttings, 18 inches long. They should be driven at least 2/3 their length. They should be spaced 8 inches to one foot apart.

2. With a hoe, cut out a small trench immediately behind the willow stakes. This trench should be 3 or 4 inches deep.

3. Bundle loose hay or pine needles together with the hands making a continuous "rope" immediately behind the stakes about 2 or 3 inches in diameter. Earth from the slope above will work down and partially cover the material.

4. Cereal grain should usually be planted in a row just above the hay or needles, and covered with a thin layer of earth.

5. The men can walk on this wattle while working on the next one above, and so on. The wattles should be spaced about 30 inches apart, slope distance.

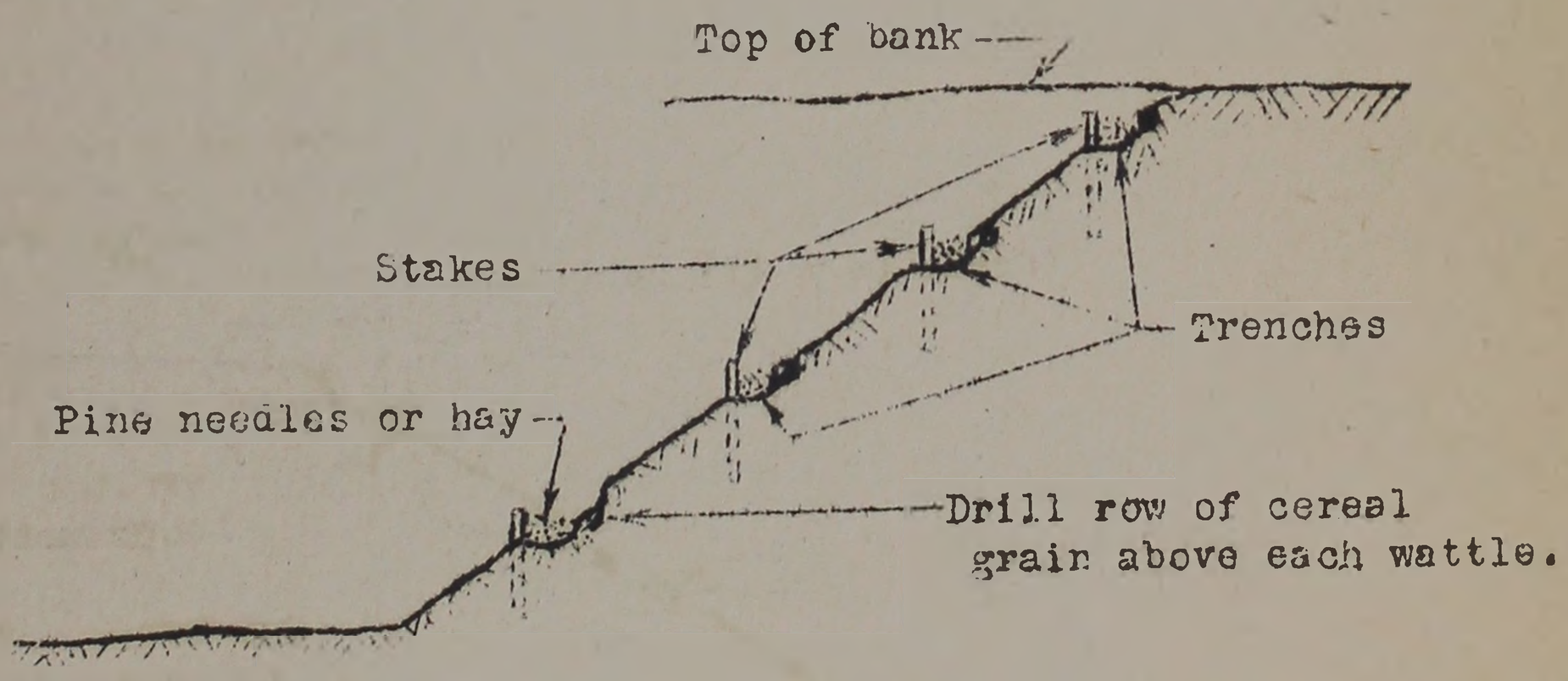

Figure 7
Side Elevation of Gully Head Showing Gully Wattles, Type C.

Type D: Wattles constructed of willow stakes, brush, and sometimes also anchor "pegs". This type, illustrated in Figure 7, is constructed as follows:

1. About 30 inches up from the bottom of the gully drive a row of willow stakes along the contour, spacing the stakes 18 inches ~~to 2 feet~~ apart. These may be the standard willow cuttings 18 inches long, but if the soil is very loose, somewhat heavier and longer stakes should be used. They should be driven in the ground at least 2/3 of their length.

2. With a hoe, cut a small trench immediately behind the willow stakes. This trench should be 4 to 6 inches deep.

3. Bundle loose brush together with the hands, making a continuous "rope" in the trench immediately behind the stakes. This "rope" should be 3 to 6 inches in diameter.

4. Holding the brush down with one hand, drive in the anchor pegs horizontally, as shown in the drawing, to keep the brush in place. These pegs are necessary only when stiff brush is used, like oak, which can not be held down by earth alone.

5. Cereal grain should usually be planted in a row just above the brush and covered lightly with soil.

6. The men can walk on this wattle while working on the next one above, and so on. The wattles should be spaced about 30 inches apart, slope distance.

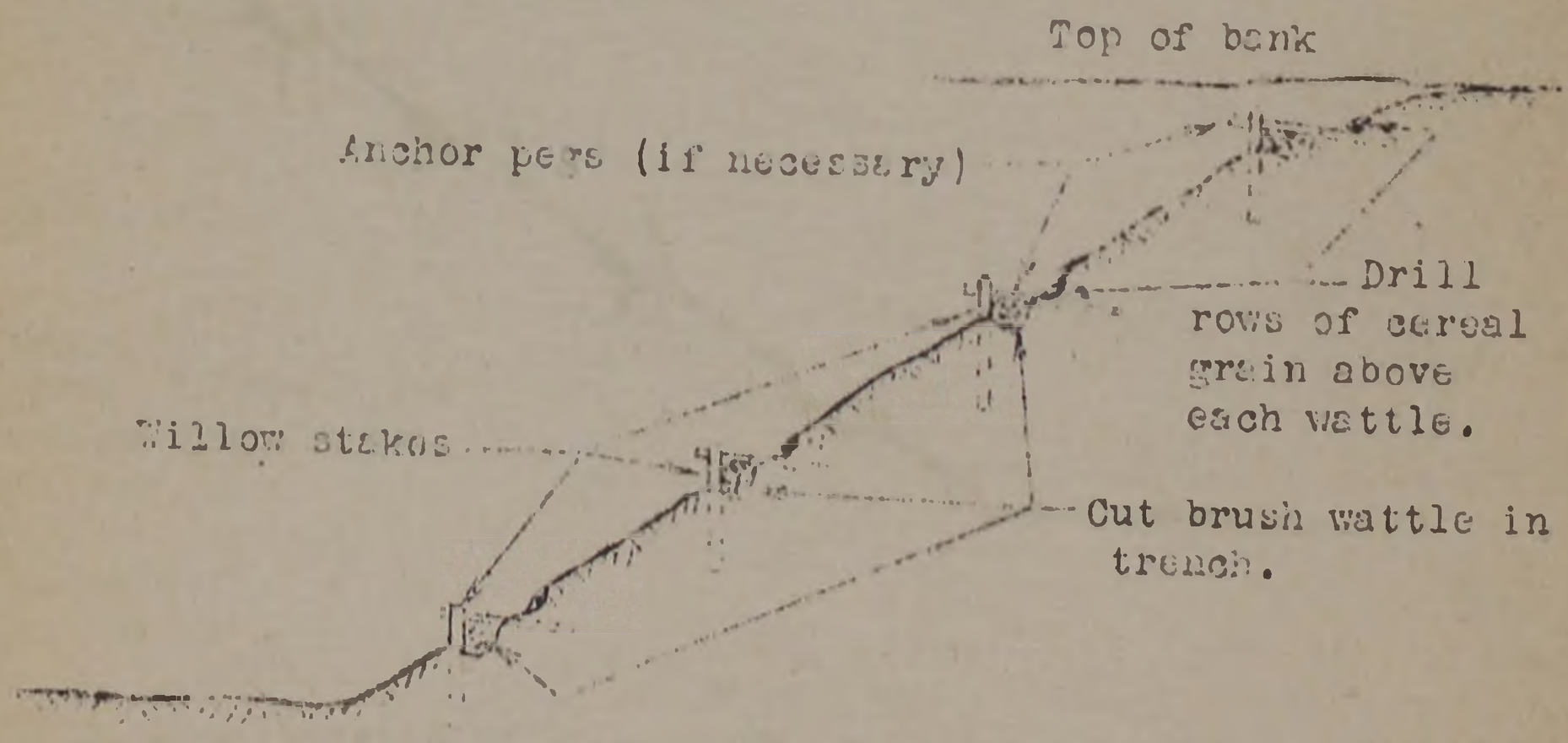
Top of bank
Anchor pegs (if necessary)
Drill rows of cereal grain above each wattle.
Willow stakes
Cut brush wattle in trench.

Figure 8
Side Elevation of Gully Head Showing Gully Wattles, Type D

Selection of Types of Wattles to Be Used

The choice of the method of wattle construction to be used depends on the soil type, looseness of the slope, soil-moisture conditions throughout the year, and on what flood flow might reasonably be expected. Normally a combination of wattle types is used, so as to get the best protection of the slope at the least cost. Illustrative combinations for different conditions are given below:

1. On a soil moist enough throughout the year to grow a heavy sod:

   a) Where the soil is not subject to rapid erosion use Type A wattles alone. This condition frequently exists along a main channel through a meadow where the banks have been slowly eating back and broadening the stream bed. It should be noted that the sod will ultimately cover the entire slope and protect that slope also against floods along the channel parallel to the wattles.

   b) Where the soil is not subjected to a heavy flow, but is of a type which erodes easily, use Type A and Type C alternately. Usually Type C wattles can be spaced 4 to 5 feet apart, slope distance, with the sod (Type A) planted midway between.

   c) Where the erosion is relatively rapid and the soil is light, alternate Type A and Type D. The Type D wattles can be spaced 3 to 5 feet apart, slope distance, with the sod (Type A) midway between.

2. On a soil too dry to grow a good sod:

   a) Where erosion is slow, use Type B, spacing the wattles 30 to 40 inches apart.

   b) Where the erosion may be expected to be somewhat faster, use Type C alternated with Type B.

   c) Under severest conditions use Type D.

3. To supplement the wattles grass or cereal grain seed can be sown for quick temporary control. For details see section on ARTIFICIAL SEEDING.

Selection of Material to Be Used for Wattles:

1. Willows: For the stakes, which form the main support of the wattles, use ordinary willow cuttings, 18 inches long and 1/2 to 2 inches in diameter. On very long, loose slopes it may be necessary to use somewhat longer and heavier stakes. Where pegs are needed to peg down the wattles use willow twigs and stems 18 inches long and 1/4 to 1 inch in diameter. If willows are scarce, some scrap lumber can be used, but there should be a willow stake at least every 4 or 5 feet along each contour wattle.

2. Hay: Any hay with long stems is good. Wheat, alfalfa or oat hay should be satisfactory. The hay should be fairly free from weeds. Special care should be taken to avoid introducing Russian thistle (tumbleweed) and Napa or star thistle.

3. Pine needles: The needles should be long, such as those from ponderosa and jeffery pine trees.

4. Brush: Brush should be used that has a dense leaf system and which will pack relatively flat in the contour trench. The following are listed as suggestions:

a) Fire sprouts of the live oak
b) California laurel
c) California coffeeberry
d) Chokecherry
e) Holly-leaf cherry
f) Incense cedar

ARTIFICIAL SEEDING

As previously mentioned, a seeding program in conjunction with other work is recommended for meadow erosion control, except where there is already a good stand of vegetative growth on the gully banks. The main purpose of sowing grass seed is to hasten the revegetation of banks which have been sloped off as part of the control work. In moist mountain meadows perennial grass seed will thrive and produce a thick sod that is excellent for erosion control. Among the most promising species for this purpose are crested wheat grass (Agropyron cristatum), timothy and some of the perennial brome grasses. For detailed information on this subject consult Circular 178, U. S. Department of Agriculture: "Artificial Reseeding on Western Mountain Range Lands" by C. L. Forsling. It should be emphasized that for success any seeding in connection with meadow erosion control must be protected from all grazing for a long enough time to permit the new grass to become firmly established. If grazing is permitted in seeded areas the effort will be wasted.

The sowing of cereal grains in contour drills on fresh bare slopes is intended only as a temporary control until the natural meadow grass can recover the slopes. The cereals make very rapid growth and leave a fibrous root system in the ground even after they die. It is usually best to use a mixture of several grains: oats, rye and wheat or barley, rather than only one species. The grain should be sown at the rate of 1/2 pound per 100 feet in furrows or drill rows, on contours midway between the Type B wattles or just above the Type C and D wattles. Broadcast sowing is less effective because grain seed does not grow well from surface sowing and because seed sown on the surface is too easily found by birds and rodents.

Cereal grain may be sown in a special manner on freshly sloped banks of dry gullies which may be subjected to flood flows. Plant the grain in drill rows at an angle of 45 degrees to the direction of flow as shown in Figure 8. This method is used supplementary to or in place of the planting of a row of willows along the toe of the bank slopes.

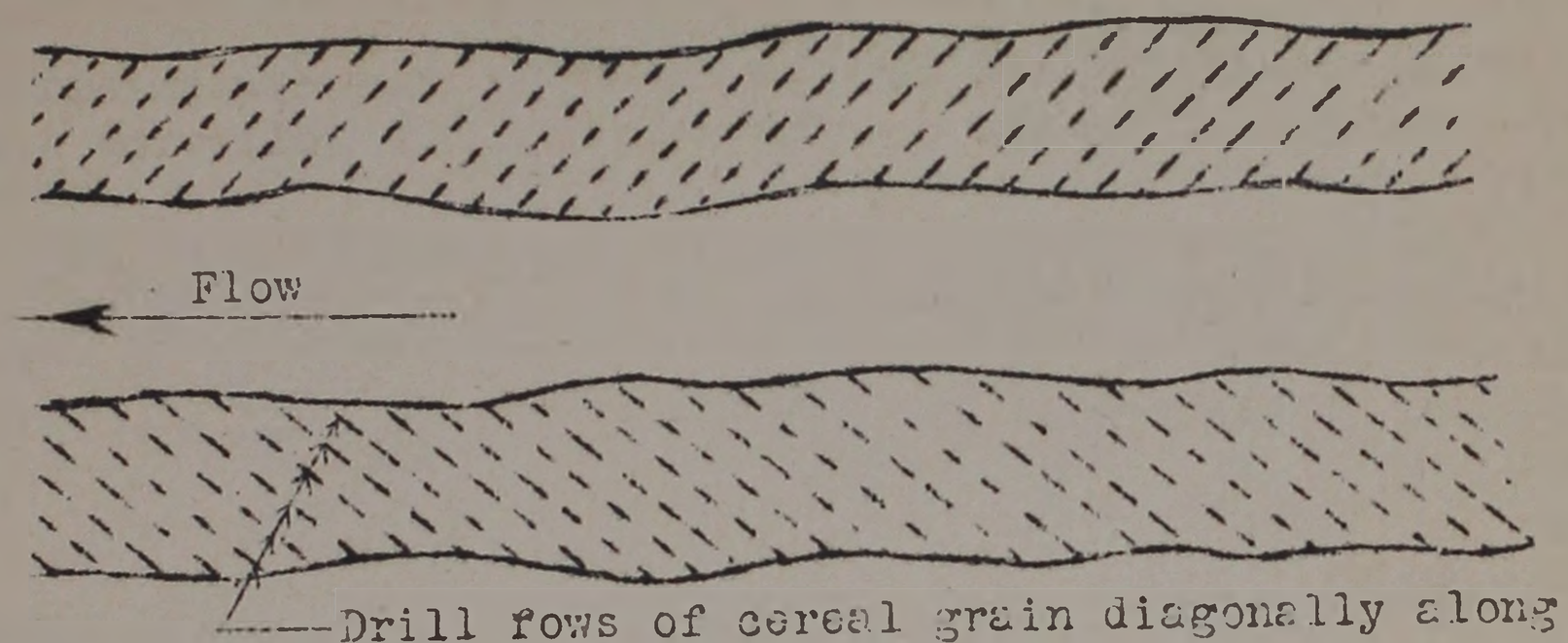

Figure 9
Plan of Gully Showing Planting of Grain Rows